

# Quiet, please!

Special tooth geometry reduces noise in external gear pumps. The SILENCE PLUS innovation offers numerous advantages in practice and can reduce system costs for customers.

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For decades now external gear pumps have demonstrated their usefulness as rugged and economical workhorses. Their primary features – pressures up to 280 bar, extremely high efficiency and low price – have come to be taken for granted. Their noise also became something of a given. But quieter pumps are now available and the noise level has become an additional purchasing criterion. Eliminating noise at the source can lower the noise level throughout the hydraulic system. As early as 1999 Rexroth introduced its SILENCE pump, responding to demands for quieter gear pumps. This is a subject to which we, as the market leader, have continued to devote attention. The result is something of a revolution: a quieter generation of external gear pumps, satisfying the following requirements:

- Drastic reductions in noise and pulsation
- Displacement volumes of from 12 to 28 cm<sup>3</sup> per revolution
- Cost-favorable
- Identical mounting templates
- Technical specifications as close as possible to the SILENCE pumps already on the market

The major factors characterizing a gear pump are its intrinsic noise, flutter in the pressure and the pitch of the sound generated. In this development project we wanted to achieve im-

provements through three central approaches: two-flank contact, helical gearing and eliminating the trapped oil cavity.

## Two-flank contact

The gears in conventional external gear pumps make contact during rotation – and thus form a seal – only at the leading flanks. The previous SILENCE pumps exhibit very close tolerances for shaft spacing and the tooth profiles. The result is zero play between the two engaging flanks. A further benefit is that the rear flank is also involved in sealing and contributes to moving the fluid. Flow is significantly more uniform and pulsation is reduced by about 75 percent. Less vibration and noise are induced in the hydraulic system as a whole.

## Helical gearing

In a first step we expanded the principle of two-flank contact by adopting helical gearing, a design commonly found in transmission construction. This has considerable impact on the pump's intrinsic noise since, due to the angular design of the teeth, transferring the contact line from one pair of teeth to the next no longer occurs across the entire width of the gear at one time. This smoothes fluctuations in the forces being transferred.

These events are distributed both spatially and across time, making for quieter running in the gear set.

### Eliminating the trapped oil cavity

Combining the two principles described was not enough to build a generation of external gear pumps where noise is drastically reduced. The development breakthrough was made when observing yet another principle. In external gear pumps using conventional toothing there is continuous alternation between one and two points of contact. Achieving uniform flow makes it necessary to maintain contact – for a certain period of time – between the previous pair of teeth while the next pair is engaging. But in the absence of other engineering measures closed, fluid-filled spaces, the “trapped oil cavities”, will form between these lines of action on both the intake and the discharge sides. The changing volume of this space leads to rapid and severe rises in pressure. These, in turn, can induce vibration. Flow noises can also be generated when this cavity opens toward the low-pressure side. We used the sophisticated calculation tools available in our development setting to eliminate most of these vibration events. But there was always a bit left over. And thus we asked ourselves: “Why not develop a pump whose design principle eliminates the trapped oil cavity?”

### SILENCE PLUS: The new generation of external gear pumps

We realized this by designing a pump incorporating helical gearing with no play. Its non-involute tooth profile eliminates the trapped oil cavities. The surfaces of the two gears are in contact not only at the flanks of the teeth but also at the top and bottom. Thus there is no abrupt transfer of contact pressure from one flank to the next. Instead there is always just a single contact line and it moves continuously along a closed-loop engagement pattern in the form of the figure 8. The axial forces impinging on the gears as a consequence of the helical toothing are absorbed by bearing elements. Hydrostatic compensation grooves help to absorb the additional forces – without wear.

We first built design prototypes proving the validity of the concept. Then we assembled a team drawn from the testing, engineering, product management, manufacturing, planning, purchasing, quality assurance and controlling departments. Supported by extensive calculations and computer-aided hydraulic simulation models, we merged the individual approaches mentioned above.

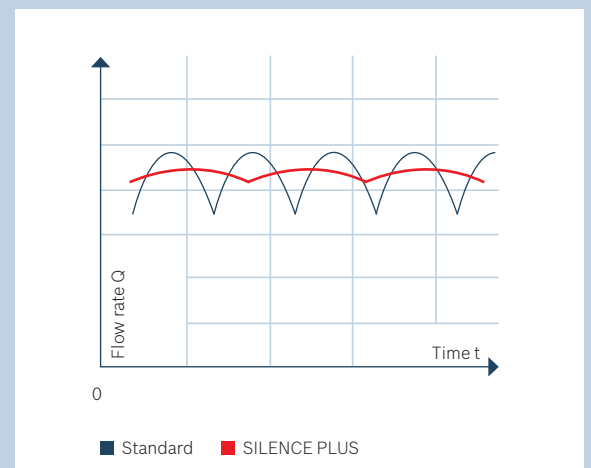
The design used for SILENCE PLUS thus contains three essential elements that together bring about significant noise reduction: the zero-play drive concept, the helical toothing and the non-involute tooth profile. What practical advantages do these engineering features offer the user in regard to inherent noise, pressure fluctuations and the pitch of the sound generated?

### Options for using the SILENCE PLUS

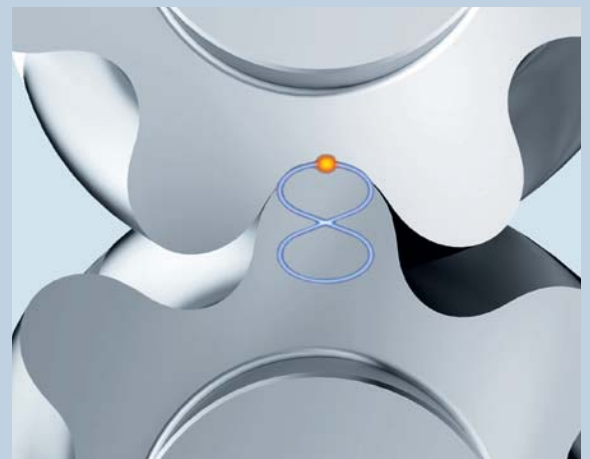
Noise reduction is particularly noticeable when an electric motor is used to drive the hydraulic pump. Here hydraulic noise



▲ The new SILENCE PLUS external gear pump reduces noise by 15 dB(A) on average.



▲ The 75 percent decrease in flutter also reduces vibration. The pump also emits a more pleasant sound, at a frequency which is 35 percent lower.



▲ This novel profile gives continuous, zero-play contact between the teeth, without cavities that trap oil.

dominates and is similar in pitch to that of an electric motor. Profiting in particular from noise reduction are those who use industrial machine tools and mobile conveyor technology. And all applications involving mobile power packs, such as tail lifts on supply trucks, are significantly quieter.

Since the intrinsic noise generated by the SILENCE PLUS units is almost inaudible at low pressures, the pump can readily be recommended for use in all kinds of lubrication, filtering and cooling circuits. The noise reduction also unfolds its full effect when lubricating transmissions in vehicles.

Pumps powered by electric motors, with virtually no hydraulic noise, are predestined for use not only in manufacturing plants and warehouses but also in supermarkets and beverage shops. Domestic applications such as passenger lifts, parking lifts and log splitters profit from the development. Trash presses behind supermarkets and hotels can be operated all day and it is acceptable for forklifts to load and unload even at night.

In the case of diesel-powered drives it is the internal combustion engine itself that makes the most noise. At first glance, attenuating hydraulic noise would seem to make little sense. But the pump, too, produces a considerable amount of sound. And this sound is in a higher frequency range so that it can be heard above the blend of lower-frequency sounds. The pitch of the intrinsic noise of the SILENCE PLUS, owing to the smaller number of teeth, is 35 percent lower. The human ear senses this as a significantly less intrusive, far more tolerable “hum”. Neighbors previously annoyed by noise from construction sites or garbage trucks in the early morning hours profit from such advances. The sanitation crew and the driver also appreciate the far lower noise level.

Direct airborne sound resulting from the pump’s intrinsic noise can be of some relevance for diesel-powered machinery.

The blower drive on agricultural seeders, for example, represents a noise load for the operator and one that can be mitigated with the use of the SILENCE PLUS.

**Less noise, lower costs**

Since the problem is attacked at the source, manufacturers can dispense with secondary measures for acoustic decoupling, insulation and encapsulation. Fewer components are required and assembly effort is lessened. These design simplifications result in cost reductions for the system as a whole.

The multitude of potential applications illustrates the extent to which hydraulic noise has crept into everyday life. Today we may have to accept some of that as an “immutable fact” - but we won’t have to put up with it tomorrow. New technology for external gear pumps points toward a future with (almost) silent hydraulic systems. ◀

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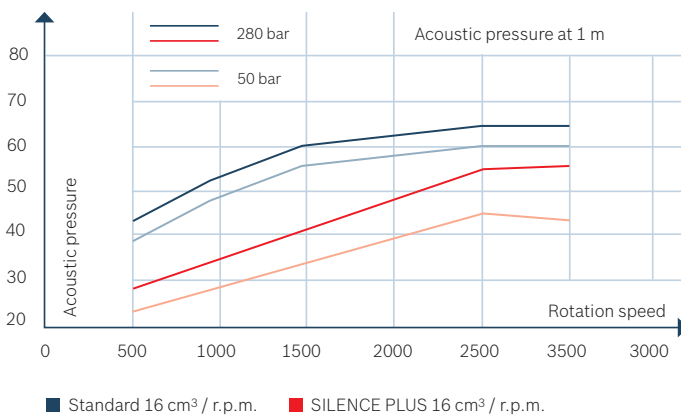
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◀ The significantly lessened noise level at the SILENCE PLUS in comparison to a conventional external gear pump.